METROPOLITAN
TORONTO

INQUIRY ON FEDERAL

WATER POLICY

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SUMMARY

This brief outlines some of the problems associated with the environmental and public health aspects of a federal water policy. Although I have emphasized Toronto's problems, many of these have national, and even international dimensions.

There are many sources of chemical contaminants to Lake Ontario which could affect Toronto's drinking water. These include the Niagara River, atmospheric deposition, sewage effluents (from both overflows and outfalls), and in-place pollutants. Probably the best known of these is the Niagara River. Sources of contaminants to the river include direct industrial and municipal discharges, as well as leaking hazardous waste disposal sites and groundwater.

Another point source of contaminants which could affect our water supplies is sewage effluents, particularly those being discharged to the lake from the Toronto area. Unfortunately, the effects of conventional treatment processes on the chemical quality of effluents are largely unknown. Non-point sources include atmospheric depositon and in-place pollutants. The relative significance of these has not yet been assessed.

There is little, or no direct evidence which shows that contaminants from these, or other, sources are adversely affecting human health but recent data suggest that fish living in chemically contaminated water are developing cancer and related health effects. There is also some evidence suggesting that disease incidence rates are increasing and could be related to the distribution and concentrations of industrially produced chemicals, such as polyaromatic hydrocarbons.

There are also concerns about Toronto's water filtration and disinfection system. Firstly, the addition of chlorine to disinfect drinking water results in the formation of trihalomethanes, and many unidentified chemicals, and there is evidence suggesting that these chemicals may be hazardous to human health over long periods of consumption. Secondly, the effectiveness of the current system in removing trace levels of chemical contaminants has been questioned, and data on Toronto's system are equivocal.

My brief goes on to identify two problems related to the management of Canadian drinking water supplies. Firstly, the federal guidelines, Ontario's drinking water objectives, and possibly other provincial standards require revision. This is partly because of the proliferation of chemicals in our society, and also because there is a need to recognize the public's demand for increased involvement in environmental issues. Secondly, there is a widening gap between our ability to detect the presence

of contaminants in drinking water and our ability to interpret these data for human health. We simply do not know what the health effects are likely to be from low level exposure, or even if there are likely to be any.

Another problem about which there is considerable uncertainty is the effects of the bacteriologial quality of Toronto's beaches on human health. There are three main sources of bacteria; wildlife populations, combined sewer overflows and storm sewer outfalls, and lastly, rivers and streams. These have all contributed to the intermittently poor quality of the beaches.

These problems have fallen into two distinct subject areas, the chemical quality of Toronto's drinking water and the bacteriological quality of Toronto's beaches. The Department of Public Health has undertaken programs in both of these areas. The chemical quality of Toronto's drinking water was the subject of a report to the Local Board of Health in 1984 and there is an ongoing summer program to assess the bacteriological quality of the Toronto beaches. These programs are described in more detail in the brief.

Having identified various water quality problems and the departmental initiatives being taken, the next section discusses some possible policies and strategies at a national level which would address these problems.

Three advocacy positions are suggested for discussions with the New York Department of Environmental Conservation, which would reduce the contamination of the Niagara River, but it is important that Canada itself should have already implemented these policies, in order for there to be any chance of success with New York State.

The problem of atmospheric deposition requires further research, after which it will probably be necessary to require offending industries to reduce their atmospheric releases.

The problem of improving sewage effluent quality probably also requires some further research to assess the effectiveness of advanced wastewater technologies. In addition, more rigid pre-treatment standards could be established for discharges into sewage systems, and recycling and safer disposal of hazardous wastes could be further encouraged.

In-place pollutants also require study, but because the nature and location of contaminated sediments varies so much, it is necessary to do this on a case-by-case basis before deciding on remediation strategies.

Contamination caused by these and other sources is assessed by chemical analysis, and to some extent by biological indicators,

such as fish and algal species. I would encourage the Canadian government to continue and even increase the funding to research projects studying biological indicators because they provide a quick and inexpensive method of assessing overall contamination levels, without complex chemical analysis.

It has been suggested that alternative water filtration and disinfection processes remove more contaminants than conventional systems. These include granular activated carbon, which is an adsorbent, ozone, chlorine dioxide and chloramines, but unfortunately little research has been done on the effectiveness of these techniques on Canadian water quality.

Another strategy which could facilitate the improvement of Canadian water quality, would be to revise current drinking water legislation, although a national survey of Canadian drinking water quality would be a necessary prerequisite. Any enforceable standards should be technically feasible, but there is a danger that they will be the lowest common denominator of all supplies. To avoid this, funds should be made available for upgrading non-compliant facilities.

In addition to implementing strategies and policies which will reduce contaminant levels, it is also necessary to further research their health effects. This can be done by encouraging research into biological monitoring methods and epidemiological studies. There are problems associated with epidemiological studies of environmental contaminants, and these have deterred researchers to some extent. But such studies are needed and should receive a higher priority.

Bacteriological contamination of Toronto's, and other, beaches is another problem for which solutions are required, although there is no single strategy that would be entirely effective on its own. Improvements in the sewage system are probably the single most important strategy, and these will also benefit the chemical quality of effluents. Another strategy being employed is to control Toronto's gull population.

In conclusion, I hope this brief has demonstrated that an important strategy to protect the public's health is the protection and restoration of the environment. As human beings we are an integral part of the environments we live in, and we cannot be separate from them. Everything that degrades the quality of those environments will eventually degrade the quality of human life to some extent. This has been called the 'ecosystem approach' and it is the only realistic long-term approach for a federal water policy.

INQUIRY ON FEDERAL WATER POLICY

1. INTRODUCTION

Firstly, I would like to thank the members of the Inquiry on Federal Water Policy for this opportunity to contribute to the development of a Canadian water policy. It should be noted that the comments below are limited to those aspects of a federal water policy that would be concerned with the protection of the public's health in Canada.

The development of a federal water policy should be a priority for the new federal government because water is such a vital resource. Water is essential for human life; a healthy person can only survive for about three days without it. Water constitutes between 50 and 75% of our body weight and most adults consume almost 2 litres a day. Contact with water, either externally through body contact, or internally through ingestion, can result in exposure to disease-causing agents. Therefore, to protect human health, water should be as free from these agents as possible. This is particularly true for drinking water, and this requirement has been recognized by the United Nations, which proclaimed the 1980's as the International Drinking Water Supply and Sanitation Decade.

My own responsibilities in water quality are predicated on the Ontario Health Protection and Promotion Act, 1983. Under this Act the Medical Officer of Health for a health unit is required to "prevent, eliminate and decrease the effects of health hazards" (section 10, subsection 1) and s/he "...may make examinations, investigations, tests and inquiries..." (section 40, subsection 4) for that purpose. The Medical Officer of Health is also required to "keep himself informed in respect of matters related to ... environmental health" (section 12, subsection 1). In addition, s/he has considerable responsibilities in the area of communicable diseases, many of which can be caused by waterborne agents. Specifically, s/he can issue an order to shut down or suspend the operation of any enterprise or activity if s/he is of the opinion that; "a communicable disease exists or may exist or that there is an immediate risk of an outbreak of a communicable disease..."

(section 22, subsection 2)

The remainder of this brief outlines several emerging water quality issues in Toronto, discusses two ongoing programs being undertaken by the City of Toronto Department of Public Health, and concludes with some suggested strategies and policies to address these issues.

2. WATER QUALITY ISUES IN TORONTO

2.1 Sources of chemical pollutants

2.1.1 Niagara River

There are many point sources of chemical pollutants which may affect the quality of Toronto's drinking water. Probably the best known is the Niagara River. Sources of contaminants to the river include industrial and municipal discharges as well as leaking hazardous waste disposal sites and groundwater.

Industrial and municipal discharges

There are many more point sources on the U.S. side of the river than on the Canadian side (see Table 1). On the U.S. side, about 12 municipal wastewater treatment plants and 90 industrial facilities have permits to discharge their effluents (over 250 MGD - million gallons per day) into the river or its immediate tributaries. Many other industrial facilities (over 300) discharge to municipal wastewater treatment plants, which in turn empty into the river.

The State Pollutant Discharge Elimination System (a permit system) is intended to control the entry of contaminants to the Niagara River. Maximum contaminant levels are set using a 'waste load allocation plan'. This divides the river into sectors and a 'tolerable total waste loading' is calculated for each sector. However, ambient contaminant concentrations are not taken into account, and neither are contaminants entering the river from non-point sources, such as groundwater infiltration. Also, although the U.S. is a party to the 1978 Great Lakes Water Quality Agreement, the water quality 'objectives' specified in the Agreement are not routinely used to derive contaminant concentrations in discharge permits. Consequently, the objectives are sometimes exceeded.

Only a few of the permits regulate the discharge of organic chemicals. Instead, they focus on conventional influences such as pH, temperature, suspended solids, oil and grease, and some metals. One report (1) showed that more than 65% of the regulated industries also used, stored, or manufactured synthetic organic chemicals.

Also, permits have been issued in the absence of independent water monitoring data, so that the N.Y. Department of Environmental Conservation (DEC) has relied on information submitted by the applicants. Similarly, they have relied on submitted monitoring data to determine whether the dischargers are in compliance with their permits. However, a recent survey by the DEC showed that

89% of the industries with discharge permits were in compliance, although only 48% of the municipal wastewater plants were (2).

It is my opinion that the Canadian government should lobby the N.Y. DEC to review its permit system. Such a review should examine whether it is appropriate to include considerations of ambient contaminant concentrations, contributions from non-point sources of contaminants, and the water quality 'objectives' of the Great Lakes Water Quality Agreement, 1978, and whether it is appropriate to expand the system to cover more of the U.S. Environmental Protection Agency's (EPA) list of priority pollutants. (There is some evidence that this is already occurring e.g., SCA Chemical Services' permit).

In Ontario there is no system for directly regulating discharges to the Niagara River. Instead they are regulated indirectly through Certificates of Approval, under the Ontario Environmental Protection Act.

There are twelve U.S. municipal wastewater treatment plants, and acccording to the U.S. EPA the four 'dirtiest' of these discharge about 328 lbs. (149 kg) of organic priority pollutants (i.e., on the U.S. EPA's priority pollutants list), 525 lbs.(239 kg) of phenols and 566 lbs. (257 kg) of heavy metals each day (3). The majority of the organic priority pollutants and almost all the phenols are discharged by the City of Niagara Falls plant. Since 1978, wastewater has received primary (settling) treatment only, because after the construction of the plant the activated carbon beds (which provide secondary treatment) failed. Reconstruction has been delayed with consequent excessive discharges to the river.

I would encourage the Canadian government to lobby to N.Y. DEC to complete the necessary remedial work on the Niagara Falls treatment plant as soon as possible.

In contrast, there are only three sewage plants on the Canadian side of the river (see Table 1). A survey conducted in 1981 of industrial and municipal point sources showed a total discharge of about 23 lbs. (10.5 kg) per day of organic priority pollutants and 156 lbs. (71 kg) per day of heavy metals. Thus the organic priority pollutants from point sources are less than 3% of the U.S. loadings and heavy metals are about 13% of the U.S. load (3). More detailed data on Canadian sources should be available soon, as part of the Niagara River Toxics Committee report.

TABLE 1

A Comparison of U.S. and Canadian Source Loadings to the Niagara River *

	U.S.	Canadian
Number of municipal sources	12	3
Number of industrial point sources	89	12
Number of hazardous waste sites	155	12
Total effluent flow from point sources (m^3 per day)	1499×10^3	236×10^3
Approximate weight of organic priority pollutants discharged per day (kg) from point sources	403	10
Approximate weight of metals discharged per day (kg) from point sources	567	71

* Compiled from data in references 3 and 4.

Hazardous Waste Disposal Sites

In 1979 a New York State report (5) identified 215 hazardous chemical disposal sites in the Niagara and Erie County area, and of these 155 are within 3 miles of the Niagara River. At least four sites (Love Canal, Hyde Park, S Area and 102nd Street) are suspected to have leaked, or be leaking, contaminants into the river.

The most infamous of these sites is probably Love Canal, where the Hooker Chemicals and Plastics Company disposed of a wide variety of chemicals between 1942 and 1952. Since 1978 most of the residents have been evacuated and the area fenced off. A

supposedly impermeable clay cap has been installed to prevent the infiltration of rain water. Although the U.S. EPA recently published a report stating that it was safe for residents to return, few, if any, have done so. Leachate from the site is collected and disposed of to the municipal wastewater treatment system and remediation costs are being covered by the U.S. Superfund.

S Area site is located on land reclaimed from the Niagara River and belongs to the Occidental Petroleum Company (formerly Hooker Chemicals and Plastics Company). It has been the subject of litigation for the last three years, but earlier in 1984 a settlement was reached in which Occidental will spend at least $30 million to remediate the site. The settlement calls for physical containment of the site, an approach that Environment Canada has found unacceptable.

The 102nd Street site is located adjacent to Love Canal and is bounded by the Niagara River. The level of the water table is very high and fluctuates with the level of the river. It is therefore likely that leached material has entered the river. In 1970, the U.S. Army Corps of Engineers issued an order to the Hooker Chemicals and Plastics Company to cease operations, cover the site with clay, and erect a retaining wall to prevent erosion of the site into the river. Relatively little hydrogeological research has been done at this site because it is located in a sparsely populated area, but its potential for contaminating the Niagara River is high.

There are three main problems with the Hyde Park landfill site. Firstly, the bottom sediments of Bloody Run Creek (flowing from the site to the river) and its tributaries have been contaminated; secondly, the installed leachate runoff collection systems are inadequate to control the movement of chemicals away from the site; and thirdly, groundwater under and adjacent to the site has been contaminated.

In 1982, agreement was reached between the EPA and the Occidental Petroleum Company. Under the terms of the agreement, the Occidental Petroleum Company is to investigate the problem and report back to the EPA on possible clean-up procedures. The clean-up itself is expected to start in late 1985.

Although these four sites probably represent the most serious potential hazards to public health, there are many other sites near the river which are not secure and could leak chemcials. These problems will remain for many years. Possibly the greatest hazard from these sites is only now becoming apparent. Evidence suggests that chemical contaminants are entering the bedrock underneath each of the four major sites described above. It is

not known if this is occurring at other sites, but it is a matter of the utmost concern because the bedrock is extremely permeable. Contaminants in bedrock will be more rapidly transported to the river than in normal subsurface groundwater flows. It is therefore important to isolate leaking disposal sites from their environment as securely as possible. The N.Y. DEC has adopted a policy of managing wastes in situ. But by pursuing this policy they are committed to extensive perpetual care of these wastes. The possibility of excavation and removal of the contaminated materials has scarcely been mentioned in discussions of remedial activities. Although the short-term financial costs would be considerably higher than those incurred by a perpetual care program, the long-term costs may be significantly less. Also, removal of the wastes would obviously be preferable on environmental grounds.

The use of landfilling as a method of hazardous waste disposal has been unsuccessful, because it has resulted in much environmental contamination. In recognition of this New York State recently announced a ban on the landfilling of liquid hazardous wastes. New disposal options are also being considered, such as incineration. I would encourage the development of new alternatives which cause the least disruption to natural resources and ecosystems.

Although individual hazardous waste disposal sites are a problem, evidence suggests that the whole Niagara and Erie County region is contaminated with organic and inorganic chemicals. For example, groundwater below the City of Niagara Falls contains chemicals in concentrations in some cases higher than the influent and effluent water of the Niagara Falls wastewater treatment plant. It has also been shown that the hydrologic gradient in the Niagara Falls area is toward the lower Niagara River. Therefore, if groundwater contaminated by leaking hazardous waste disposal sites is widespread, regional groundwater movement will add to the contamination of both the Niagara River and Lake Ontario.

2.1.2 Atmospheric deposition

Until recently the impact of atmospheric deposition on water quality has been neglected. To compensate for this the EPA funded two reports on organic and inorganic contaminants, respectively, in the Great Lakes ecosystem (6,7). There is also an International Joint Commission (IJC) task force investigating this problem.

Estimates of atmospheric deposition are somewhat vague because of uncertainties about atmospheric concentrations, meteriological conditions, and other factors. For organic contaminants, dry deposition is significantly greater than wet deposition. The data

also suggest that total deposition of organic chemicals to each of the Great Lakes is proportional to their surface area. Estimates of annual deposition of organic and inorganic chemicals to Lake Ontario are shown in Table 2 (8).

TABLE 2

Annual Deposition of Organic and Inorganic Chemicals to Lake Ontario

	metric tonnes/year
Total PCBs	2.3
Total DDT	0.14
alpha-BHC	0.77
gamma-BHC	3.7
Dieldrin	0.13
HCB	0.39
Methoxychlor	1.9
Endosulphans	3.7
Zinc	948
Lead	379
Copper	95
Cadmium	28
Nickel	76
Iron	1,520
Total PAHs	38
Anthracene	1.1
Phenanthrene	1.1
Pyrene	1.9
Benzo (a) anthracene	1.1
Perylene	1.1
Benzo (a) pyrene	1.8
DBP	3.7
DEHP	3.7
Total Organic Carbon	4.6×10^4

The figures show that large amounts of organic and inorganic chemicals are deposited every year. The sum of the weights of organic chemicals deposited is much less than the estimated weight of total organic carbon deposited into the lake. This suggests that some sources of organic carbon remain to be identified and measured. For example, it is likely that dioxins (from

incinerators and other sources) are being atmospherically deposited into the lake.

Atmospheric deposition is probably a major source of pollutants to Lake Ontario and the other Great Lakes and research into the amount of deposition, its nature, origin, and how it might be prevented has only just started. In my opinion, the Canadian government should advocate for the IJC to undertake more research on this subject to determine the sources, nature and effects of atmospheric deposition more fully.

2.1.3 Sewage

There are four sewage treatment plants in Toronto that discharge directly or indirectly into Lake Ontario. In addition, there are approximately 16 storm sewers and 25 combined sewer overflows that empty directly into the central waterfront area. Until recently, the chemical composition of effluents from the treatment plants, storm sewer outfalls and combined sewer overflows, were largely unknown. But sampling and analyses conducted in 1984 has shown that significant amounts of chemicals are being discharged to Lake Ontario via this route. Little is known about the origin of hazardous chemicals in sewage. Presumably a proportion originates from industrial discharges to the system, and also from household wastes (e.g. chemicals used in home renovations). Other sources include urban runoff. Conventional sewage treatment plants were not designed to treat chemical effluents, but they probably do not pass through the process unaltered. Unfortunately no data are available because the appropriate sampling and analysis has not been conducted. Such data would be useful to assess the effectiveness of conventional sewage treatment. It would also indicate whether or not advanced wastewater treatment processes are desirable. These processes involve carbon bed filtration and are currently being developed in the U.S.

Discharges to the sewer system are regulated by Metropolitan Toronto By-law No. 148-83. It establishes maximum permissible concentrations for discharges into sanitary or combined sewers, and also for discharges into storm sewers. The purpose of this and other sewage by-laws is to protect the treatment facilities and personnel, rather than to minimize the discharge of pollutants to the ecosystem. While the above-mentioned objectives are necessary, municipalities should be encouraged to consider the impacts of sewage effluents on local ecosystems.

Most municipal sewage by-laws, including Toronto's are based on a model by-law prepared by the Ontario Ministry of the Environment and the Ontario Municipal Engineers Association, but this model by-law should now be updated. This is partly because it does not cover many of the potentially toxic chemicals known to be in

sewage, and also so that it can provide a basis to control all existing or potential waste discharges to sewers .

2.1.4 In-place pollutants

In-place pollutants are those which are already present in the ecosystem, such as in contaminated sediments. The significance of in-place pollutans has only been recognized recently, and they are a particular problem in the Great Lakes ecosystem where 17 of the 18 Class A "areas of concern" identified by the IJC are affected by in-place pollutants. The main difficulty is that remediation of polluted ecosystems can often necessitate the removal of contaminants, which can result in increased exposure in the short term while, for example, sediments are being dredged. The alternative is to confine contaminants in situ by isolating them from the rest of the ecosystem. Obviously this approach is only feasible if they are located in non-erosional areas. The IJC has recently suggested that "hastening the burial of contaminated sediments ... can be an ecologically sound and economically viable method of managing contaminated sediments."

In my opinion, the management of in-place pollutants should be considered on a case-by-case basis. This is because ecosystems are highly variable and it would be inappropriate to establish a general rule.

2.2 Fish cancer and other diseases

Recently it has become evident that fish living in chemically contaminated water are developing cancer and related health effects. A study conducted in the mid 1970's on young English sole in Vancouver harbour showed that overall 58% had skin papillomas and that the incidence rates were proportional to the proximity of the fish to sources of chemical contaminants. Researchers in Washington State, found a similar relationship for liver cancers in English sole in Puget Sound. Another study showed that although tomcod fish have now returned to New York's Hudson River, 2 year-old fish have an 80% incidence of liver cancer. In addition to cancer, developmental abnormalities are also common.

In the Great Lakes, hyperthyroidism and goiter have been reported in coho salmon. The highest incidence rates are in Lake Erie, where almost 100% of the fish are affected. Cancerous tumours have also been reported on the reproductive organs of carp and goldfish in Lakes Michigan, Erie and Ontario, rendering the affected individuals sterile. Samples of the same species taken from the same locations 30 years ago had no tumours.

In badly contaminated areas of the Great Lakes, such as Hamilton Harbour, up to 41% of white suckers have papillomas. This is a naturally occurring skin tumour usually found on less than 1% of a given fish population. Although they are probably caused by a virus, there is evidence suggesting that their development is stimulated by chemicals in water.

Unfortunately white suckers are not the only fish with papillomas. Brown bullheads, caught in the Niagara River, Lake Erie, the Buffalo River and the Black River also have high incidence levels. Many of them also have liver cancers and other health problems which may be fatal. This is because normal bullheads live 7 or 8 years but in a sample of over 1000 fish, researchers found only a dozen 5 year olds and no older fish.

Despite these high disease incidence rates, it is difficult to establish conclusively that they are the result of industrial pollution. One study of the Buffalo River does suggest a link (9). Samples of sediments contaminated with polyaromatic hydrocarbons (industrial chemicals) were collected, and an extract from the sediments was painted onto the skin of one group of bullhead, and fed to another group. Within a year the skin-painted group started to develop papillomas and 8/10 fish which were fed the extract suffered liver damage, including tumours. Both types of tumours were similar to those seen in fish caught from the sediment collection site. This suggests that industrially produced polyaromatic hydrocarbons can cause skin tumours and liver damage in fish. But links are often not so easy to establish and more data are needed on the age and sex profiles of affected fish populations, the range and feeding habits of fish and the overall frequencies and distributions of fish tumours.

Not only is it difficult to find causes for these high disease rates, but also to estimate what the implications are for human health. Diseases in fish may be an 'early warning system' for humans, because their gills are exposed to larger volumes of water than human gastro-intestinal tract, and both are assimilative organs. Fish are therefore exposed to relatively larger amounts of pollutants which can be absorbed into the body.

In addition, eating contaminated fish may be a risk to human health. Fish can bioaccumulate chemicals many hundreds of thousands times. The Ontario Ministry of the Environment publishes an annual guide to eating Ontario sport fish which provides advice on the maximum amounts of fish that can be safely eaten. But research at the University of Guelph showed that Great Lakes fishermen often ignore the Ministry's guidelines and eat up to 200 pounds of fish a year. Other research at Guelph indicated that when laboratory rats were fed Great Lakes salmon, they developed

thyroid, liver and immune system disorders within 3 months. Direct evidence of human health effects has not been found.

Indirect evidence is beginning to emerge in the U.S. Recently it was discovered that 5 locations which have a high prevalence of malignant fish cancers are also areas where the human cancer mortality rates are unusually high. Although this may be an oversimplification, it does suggest an association between the fish and human cancers.

There is, however, not much evidence suggesting that the incidence rates of human cancers that could be caused by industrial contaminants are increasing. So although it is likely that industrial discharges of chemicals are causing adverse health effects in fish, it is unclear what the implications are for human health. Whatever the explanation, this issue deserves the attention of public health professionals and environmental health policy-makers.

2.3 Water filtration and disinfection in Toronto

There are four water filtration plants in Toronto and although the methods used at the different plants vary slightly, the same general principles are used. The process involves prechlorination, coagulation with ferric chloride, rapid sand filtration and disinfection.

My main concern with the process is in the disinfection step. When chlorine is added to disinfect drinking water, many chemical reactions occur. In the best known of these, naturally occurring humic and fulvic acids react with the chlorine to produce chloroform and other trihalomethanes (dibromochloromethane, bromodichloromethane and bromoform). Chloroform is a potential human carcinogen, and the other trihalomethanes have been shown to be mutagenic in the Ames test.

Other halogenated and non-halogenated products may also result from the reaction of humic and fulvic acids with chlorine, but the adverse health effects of these substances are largely unknown.

In addition to the reaction between chlorine and humic acids, other substances present in raw water may also react with chlorine. Phenols have been shown to react to form chlorophenols, and polyaromatic hydrocarbons react to form a variety of chemicals, some of which are potential or suspect carcinogens. Although current attention on the carcinogenicity of trihalomethanes may be valid, the possible adverse health effects of all the chemical products of chlorination should be investigated and put in perspective relative to the advantages of chlorine as a disinfectant.

It is now well-established that chlorination increases the mutagenicity (in the Ames test) of drinking water (10), and Cheh et al (11) concluded that chlorination was responsible for non-volatile as well as volatile mutagen production. Trihalomethanes comprise the major portion of volatile compounds in treated drinking water, but they only cause a fraction of the mutagenic activity (12). This suggests that much of the activitity is due to non-volatile compounds. Evidence shows that not only are most mutagens carcinogenic (13), but also that there is a correlation between the potency of mutagens and their carcinogenic ability (14). Therefore this large unidentified portion of mutagenic activity, consisting of non-volatile compounds, should be regarded as potentially carcinogenic.

As mentioned above, chlorination increases the mutagenicity of drinking water. One study of Great Lakes water showed that chlorinated water was more mutagenic than raw lake water by factors of between 2 - 10 times (15). This suggests that chlorination is the largest single source of potentially hazardous chemicals to drinking water. However, in making this statement I acknowledge the tremendous public health benefits that have resulted from the use of chlorine, such as the virtual eradication of waterborne communicable diseases such as typhoid, cholera, dysentery and infectious hepatitits.

Another area of concern is the effectiveness of the existing process in removing both organic and inorganic chemical contaminants. The existing water filtration and disinfection procedure was not designed to remove chemical contaminants from drinking water, although it undoubtedly affects both organic and inorganic chemicals present. The U.S. study, Drinking Water and Health (16), discusses the removal of organics by coagulation, sedimentation and filtration. It concludes that some organics adsorb either on natural particles or on those formed during coagulation, and that they are removed when the particles are filtered out. This hypothesis is supported by evidence showing total organic carbon (TOC) removals of between 25 and 60%. Humic acids have been shown to be removed most efficiently at acid pH. Lake Ontario water is slightly alkali, so removal may not be good. Data on dissolved organic carbon in Toronto's raw and finished water (17), show that there is only a 5 - 10% decrease after treatment.

Removal of specific organics, such as polyaromatic hydrocarbons and some organochlorine pesticides, has been demonstrated to occur in the coagulation process (16), but data on Toronto's filtration plants are equivocal. When concentrations of specific synthetic organics are compared before and after the treatment process, it can be seen that the process has little effect. But because synthetic organics (other than trihalomethanes) are only

infrequently detected in Toronto's drinking water, this conclusion is based on few data.

Evidence of the removal of inorganics is also equivocal. Most inorganics in Toronto's drinking water are present at concentrations at which they may be soluble, although this will depend on such factors as pH and temperature. Concentrations of inorganics before and after treatment show no consistent patterns, either for inorganics generally, or for specific ones. In some instances concentrations increase after filtration, in some they stay the same, and in others they decrease. There is also variability in the behaviour of individual chemicals. Possible reasons for this include the presence of trace elements in the chemicals used in the filtration and disinfection processes. The only conclusion that can be drawn is that the existing water filtration and disinfection processes affect concentrations of inorganics unpredictably.

2.4 Drinking water legislation

The federal drinking water guidelines, Ontario's objectives and possibly other provincial drinking water standards are in need of revision. This revision is necessary for two reasons; first, the proliferation of chemicals in our society, and second, the need to recognize the public's demand for increased involvement in environmental issues.

Since the Second World War there has been an unprecedented proliferation in the manufacture and use of synthetic chemcials. They permeate almost every aspect of our daily lives, but because many do not occur in nature, natural ecosystems do not have efficient mechanisms to degrade them. This is seen, for example, in the persistence of DDT in the aquatic environment even though its production and use were restricted several years ago.

Water, being a major part of the natural environment, is obviously affected by persistent chemicals. Although the concentrations of these contaminating chemicals may not seem large, and in some cases may be below present detection levels, we should be cautious about their presence because of uncertaintities about possible health effects that could result from exposure to, not only individual chemicals present, but also from exposure to synergistic interaction between chemicals.

The second reason why our drinking water standards are in need of revision is that the public is becoming increasingly concerned about the presence of chemicals in the environment and is demanding more involvement in environmental policy decisions. People are suspicious of the air they breathe and waste products emanating from smokestacks. We wish to know more about the water

we drink. In these, and other cases, we are all involuntary recipients of environmental pollution, and wish to exercise some control. At present policy decisions are mostly made behind closed doors with little or no public input. In my opinion this situation should be changed and the public should be more involved in decisions which could result in involuntary exposures to hazardous chemcicals.

2.5 Lack of knowledge about the effects of chemical exposure

My report on the quality of Toronto's drinking water identified some 83 chemicals which have been detected in Toronto's drinking water on one or more occasions between 1971 and 1983. For the vast majority of these, our knowledge of their individual health effects is incomplete. Our knowledge of their combined effects is even scantier. Some studies of combined effects have been done, but these only lasted a maximum of thirteen weeks.

Many chemicals have been detected in parts per billion or parts per trillion, but we cannot dismiss these seemingly low concentrations as being insignificant. Extrapolations of animal studies suggest these concentrations may be biologically significant for some chemicals. For others with unknown health effects I advocate a cautious approach to ingestion through drinking water. We simply do not know what the health effects are likely to be from low level exposure, or even if there are likely to be any. This is a source of frustration for everyone, but probably most of all to the ordinary citizen who hears conflicting views from different 'authorities'.

Discussions of the health effects associated with hazardous chemicals in drinking water have concentrated on cancer, mutagenesis, teratogenesis, birth defects and some short-term effects, such as disturbances of the central nervous system. But we should not preclude the possibility of the occurrence of other health effects which have not yet been studied in such detail. Other possible effects might include behavioural and psychological effect, suppression of the immune system and reproductive effects, such as changes in fertility rates.

Compounding these difficulties is the widening gap between our ability to detect chemicals and our ability to interpret detected levels in terms of human health effects. Public officials are responsible for reporting new data to the public, but if their significance cannot be explained, the possibility of generating public alarm adds a new dimension to that repsonsibility. Different jurisdictions contribute to this problem by issuing different guidelines or standards. The public's interpretation is that one jurisdiction is saying that a given chemical concentration is safe, while another is saying it is unsafe. This

severely threatens the credibility of government agencies in the public's eye.

Another problem is that statements asserting that our drinking water is 'safe' do not reassure the public. Although Toronto's drinking water meets the Health and Welfare Canada guidelines, this can no longer be construed as absolutely 'safe'. To some people the word 'safe' implies freedom from any risk, and clearly water containing carcinogens, or even potential carcinogens such as trihalomethanes, is not free from risk. I therefore suggest that the word 'safe' be eliminated from discussions on drinking water. Instead we need to educate the public on risks associated with drinking water. Such risks should not be imposed, but the public themselves should be involved in discussions about what risks are acceptable, and hence in the standard setting process itself.

2.6 Bacteriological quality of Toronto's beaches

In 1983, all but two of Toronto's beaches were placarded with signs warning the public against swimming, because of high bacterial concentrations in the water. Concerns about the bacterial contamination of swimming beaches are not new in Toronto, and the Department of Public Health has been monitoring the situation since 1956. This program is discussed in section 3.2. However, what was new in 1983 was firstly that a new water sampling protocol was adopted and secondly that the summer was both extremely dry and very hot. These combined circumstances resulted in unusually high levels of total coliform, fecal coliform and fecal streptococcus bacteria.

There is general agreement that there are three main sources of bacteria to the Toronto waterfront:

a) wildlife populations

b) combined sewer overflows and storm sewer outfalls

c) rivers and streams

These are discussed below.

Note: It is unlikely that bacteria reproduce in significant numbers in the lake, because the water temperature is not high enough. However, reproduction could occur in very shallow, warm water or at the water surface, where the temperatures are significantly higher than those elsewhere in the lake.

Excrement from wildlife populations, particularly Canada Geese and gulls is thought to be partially responsible for the bacterial

contamination of Toronto's beaches. There are large numbers of both of these species within Metropolitan Toronto, in fact in 1983 there were approximately 123,500 pairs of ring-bill gulls nesting within 100 km of the City of Toronto, most of them being located on the Leslie Street spit. Obviously, considerable amounts of excrement are produced by such numbers of birds. In April 1984 this problem was addressed by the Canadian Wildlife Service, which sprayed kerosene on some gull nests on the Leslie Street spit, thus preventing the eggs from hatching. Further spraying was prevented by local conservation groups.

The second factor involved is the bacterial contamination of combined sewer overflows and storm sewer outfalls. Chemical contamination of sewers has already been discussed in section 2.1.3, but bacterial contamination is also a significant problem. A proportion of the bacteria enter the lake via the combined sewer overflows. In prolonged or heavy rainfall these sewers, which contain both sanitary sewage and storm water, overflow into the lake with the result that raw sewage can pollute the nearshore zone. In addition to the combined sewer overflows, many storm sewers empty into the lake or into the many local rivers and streams which eventually drain into it. As has been mentioned previously, urban runoff water is not clean, and bacteria can reproduce in such water, using the suspended solids and dissolved organic and inorganic chemicals as nutrients.

The third factor contributing to bacterial levels of the beaches is the bacterial contamination of the many rivers and streams which drain the Toronto area watershed, and eventually empty into Lake Ontario. The extent of this problem is currently being assessed in a five-year study being undertaken by the Ontario Ministry of the Environment. The study, the Toronto Area Watershed Management Strategy Survey (TAWMS) was designed to assess the extent of both bacterial and chemical contamination in the Toronto area watershed, and to suggest strategies to improve the existing situation. This study identified the Humber River as a main source of bacterial contaminants to the Western Beaches. In turn, it is thought that these bacteria originate from combined sewer overflows and storm sewer outfalls which empty into the Humber River upstream.

Possible strategies to reduce the bacterial contamination of the Toronto beaches are discussed in Section 4.6 below.

3. RECENT INITIATIVES TAKEN BY THE MEDICAL OFFICER OF HEALTH

3.1 The chemical quality of drinking water

In September 1981 Pollution Probe presented a report entitled "Toxics on Tap: A report on the quality of Toronto drinking water" to the City of Toronto's Local Board of Health. This report discussed the chemical quality of Toronto's drinking water and argued that the present filtration and disinfection system should be improved. Largely in response to this report, the Local Board of Health requested that the Medical Officer of Health prepare his own in-depth report, in cooperation with members of Pollution Probe, City of Toronto Department of Public Works and the Metropolitan Toronto Works Department, which would:

a. summarize current knowledge of the health effects of organic and heavy metal contaminants in drinking water;

b. review the need for and feasibility of upgrading the current purification system; and

c. report on the extent to which Toronto's sewage system is contributing to the contamination of Lake Ontario.

The goals of the report were therefore to:

- Assess whether there is, or is not a potential or actual hazard to health resulting from the consumption of Toronto's drinking water;

- Determine the magnitude of the potential or actual health hazard, should such exist;

- Review the health implications of alternatives to conventional filtration and disinfection techniques; and

- On the basis of a. to c., above, recommend whether or not the existing water filtration and disinfection system should be upgraded.

A final report was received by the Local Board of Health on April 24, 1984 and is still under consideration. It discussed some of the sources of chemical contaminants which could potentially affect the quality of Toronto's drinking water and the chemical status of Lake Ontario. Current filtration and disinfection procedures in Toronto were also reviewed, as well as the influence of the distribution system on water quality. As part of this study chemical analysis of ten brands of bottled water was undertaken, the results being compared with those from a sample of tap water. The report also evaluated the scientific basis for the existing

federal drinking water standards and reviewed the potential health effects of chemicals that have been identified in Toronto's drinking water. It concluded with an assessment of the public health implications of alternative filtration and disinfection systems. An appendix to the report presents a preliminary epidemiological study of health risks in relation to drinking water in Toronto and several other selected Ontario municipalities.

In summary, the report was unable to demonstrate that the consumption of Toronto's drinking water has resulted in any observed health effects. An extrapolative experimental technique did suggest that a minute fraction of the cancer incidence in Toronto may be associated with the ingestion of trihalomethanes from drinking water. This estimate could not be supported scientifically because the predicted increased incidence was so small. Moreover, the estimate was not intended to imply that Toronto's water causes cancer, but rather that there are risks. Acknowledging the lack of information on the effects of exposure to chemicals, the report recommended that experimental alternatives to the existing filtration and disinfection system be investigated to determine whether effective removal of trace chemicals that have been previously identified in Toronto's water, is possible, and whether suitable alternative disinfectants exist.

The report made a total of 32 recommendations which were directed to many different government agencies (both U.S. and Canadian) concerned directly and indirectly with the quality of Toronto's drinking water. These recommendations are summarized below.

1. That the Commissioner of the New York State Department of Environmental Conservation be requested to review the basis for the SPDES (State Pollutant Discharge Elimination System) permits. Such a review should examine whether it is appropriate to include considerations of ambient contaminant concentrations in the Niagara River, chemical contaminants entering the river from non-point sources, and the water quality 'objectives' of the Great Lakes Water Quality Agreement, 1978, in discharge permits.

2. That the Commissioner of the New York State Department of Environmental Conservation be requested to encourage the regulation of more priority pollutants in all new and renewed SPDES permits.

3. That the Director of Utilities for the City of Niagara Falls, New York be requested to complete the necessary remedial work on its wastewater treatment plant as soon as possible.

4. That the Commissioner of the New York State Department of Environmental Conservation and the Administrator of the U.S. Environmental Protection Agency be requested to consider the excavation and removal of contaminated materials as an alternative to *in situ* management of the leaking waste disposal sites most likely to contribute to the contamination of the Niagara River.

5. That the Commissioner of the New York State Department of Environmental Conservation and the Administrator of the U.S. Environmental Protection Agency be requested to consider the development of environmentally sound disposal options as a matter of utmost importance. This should include the development of programs to minimize the quantities of hazardous wastes produced, and to improve their quality wherever possible.

6. That the Commissioner of the New York State Department of Environmental Conservation and the Administrator of the U.S. Environmental Protection Agency be requested to investigate the extent and levels of the chemical contamination of groundwater in the Niagara and Erie County region, and to estimate the likely effects on water quality in the Niagara River and Lake Ontario.

7. That the Minister of the Enviroment for Ontario be requested to continue to work toward abatement strategies for the Toronto watersheds.

8. That the Commissioner of the Works Department, Metropolitan Toronto be requested to include computer modelling of the dispersion characteristics of the most significant chemicals (e.g., chlorine and heavy metals) identified in the Main treatment plant effluent, in the planning process for the new outfall pipe.

9. That the Commissioner of Public Works Department, City of Toronto, be requested to undertake a comprehensive chemical analysis of all storm sewer outfalls and combined sewer overflows at least once a year, using the U.S. Environmental Protection Agency's list of priority pollutants as a basis.

10. That the Commissioner of the Works Department, Metropolitan Toronto, be requested to chemically analyze effluent samples from all four Metropolitan Toronto sewage treatment plants at least once a year using the U.S. Environmental Protection Agency's list of priority pollutants as a basis.

11. That the Commissioner of the Works Department, Metropolitan Toronto, and the Commissioner of the Public Works Department,

City of Toronto, be requested to integrate the programs of chemical analysis mentioned in recommendations (9) and (10) above, by using the same list of chemicals, and standardized sample collection and analytical procedures.

12. That the Minister of the Environment for Ontario be requested to define, or have defined, and make public, "zones of non-compliance' with the Provincial Water Quality Objectives for point sources of contaminants to the Toronto waterfront.

13. That the Minister of the Environment for Ontario be requested to develop a consistent year-round monitoring program for the Toronto waterfront, to be based on an assessment of the relative contributions of all point sources of chemical contaminants.

14. That the Chairmen of the Great Lakes Science Advisory Board and the Water Quality Board of the International Joint Commission be requested to investigate the atmospheric depositon of organic and inorganic chemicals into Lake Ontario to the fullest extent possible.

15. That the Minister of National Health and Welfare be requested to investigate the health effects of the non-volatile mutagenic fraction of chlorinated drinking water in animals to determine its carcinogenic potential.

16. That the Minister of National Health and Welfare be requested to initiate a research program to investigate possible alternatives to the use of chlorine as a drinking water disinfectatnt. This could also include an evaluation of alternatives to conventional filtration methods, such as granular activated carbon.

17. That the Commissioner of the Works Department, Metropolitan Toronto, be requested to identify any additional chemicals present in Toronto's drinking water at the most sensitive detection levels possible which are not included in regular analyses, by performing a complete gas chromatograph/mass spectrometer or electron capture scan on one set of drinking water samples in 1984.

18. That the Minister of National Health and Welfare and the Minister of the Environment (federal) be requested to undertake a national survey of organic and inorganic chemicals in Canadian drinking water.

19. That the Commissioner of Public Works, City of Toronto, be requested to investigate the extent of leaching of organic chemicals from plastic pipes and pipe sealants. Such a study

should include the determination of actual concentrations in areas of the Toronto distribution system where plastic pipe is used.

20. That the Medical Officer of Health, in cooperation with the Commissioner of Public Works, City of Toronto, be requested to prepare a proposal for systematic testing for chemicals in tap water in the City of Toronto, and that other municipalities be encouraged to do the same.

21. That the Commissioner of Works, Metropolitan Toronto, be requested to study possible methods of reducing trihalomethane concentrations in the distribution system.

22. That the Minister of National Health and Welfare be requested to chemically analyze brands of bottled water sold in Canada, on a regular basis.

23. That the Minister of National Health and Welfare be requested to assess the chemical quality of brands of bottled water sold in Canada with the Guidelines for Canadian Drinking Water Quality, 1978, as well as with the bottled water regulations under the Food and Drugs Act.

24. That the Minister of National Health and Welfare be requested to reconsider the policy of permitting the sale of tap filtration devices in Canada.

25. That the Minister of National Health and Welfare be urged to consider confining the use of the "no observed effects levels" method of standard setting to non-carcinogenic chemicals in drinking water.

26. That the Minister of National Health and Welfare be requested to recommend a zero level of exposure to carcinogenic chemicals, where possible. Where this is not possible, it is recommended that exposure levels to carcinogens should be set using risk levels, rather than "no observed effects levels".

27. That the Minister of National Health and Welfare be requested to develop a mechanism for encouraging public participation when setting drinking water and other environmental standards, by incorporating a time period for public review and public hearings before standards are finalized.

28. That the Minister of National Health and Welfare be requested to consider setting drinking water guidelines for a comprehensive range of organic chemicals. This could be based on the U.S. Environmental Protection Agency's list of priority pollutants.

29. That the Medical Officer of Health, City of Toronto, be requested to prepare a short report on the implications of mandatory drinking water standards for chemicals.

30. That the Minister of National Health and Welfare be requested to investigate the possible interactive multi-generational effects of long term exposure to chemcials in drinking water.

31. That the Minister of National Health and Welfare be requested to conduct animal studies on the possibility of such health effects as behavioural and psychological effects, suppression of the immune system and changes in fertility rates, and their relationship with the ingestion of hazardous chemicals, particularly through drinking water.

32. That the Minister of the Environment for Ontario be requested to consider initiating a comprehensive field study to evaluate alternative disinfection and filtration techniques, and report back to the Local Board of Health. Such a study could include evaluations of the effectiveness of ozone (as a disinfectant and in eliminating organics) and granular activated carbon. It is further recommended that combinations of alternative technologies (for example, granular activated carbon and ozone) and combinations of alternative and conventional technologies (for example, granular activated carbon and chlorine) be evaluated. It is also recommended that this study be undertaken in collaboration with the Metro Toronto Works Department, using Toronto's drinking water supply, and the results be analyzed in consultation with the Medical Officers of Health for Metropolitan Toronto.

3.2 Monitoring the bacteriological quality of Toronto's beaches

Since 1956 the City of Toronto Department of Public Health has been conducting a programme of bacteriological monitoring of its lakefront beaches. At the outset the effort was shared with the now defunct Ontario Water Resources Commission (OWRC) which provided the laboratory expertise while City health inspectors carried out the field work. In those early days the becteriological parameters used were total coliform, fecal coliform and fecal streptococcus. These were enumerated, using the "multiple tube fermentation" or "most probable number" test.

In 1967 the OWRC was replaced by the Ministry of the Environment and the partnership continued. Over the years as laboratory methods improved the "most probable number" test was replaced by the "membrane filter" technique which reduced sample turn-around time by one half. Beaches were placarded from time to time during

the period from 1956 through 1971. From 1972 to 1982 there were no beaches placarded and water quality remained consistently good. Up to this point all samples were taken from a boat supplied by the Toronto Harbour Police. Although every effort was made to sample at the same location and depth, varying climatic conditions often made such consistency impossible, causing doubts about the validity of some of the data.

In 1983 a new approach was adopted. As well as the boat samples, additional samples were collected from the shore using a reaching pole to approximate the 1.5 metre depth suggested by Cabelli et al (19). Some samples were taken by personnel wading into the water to achieve an even greater measure of depth consistency. These measures, accompanied by an inordinately hot and dry summer, resulted in the placarding by mid summer of all but two of Toronto's beaches in 1983. The two open beaches were Hanlan's Point and Ward's Island both located on the lake side of Toronto's Islands. The use of the three different sampling modes again posed some questions as to scientific validity and accordingly in 1984 a consistent and intensified sampling programme was undertaken.

Historically the Western beaches had the poorest bacteriological quality with a gradient of gradual improvement as one moved eastward away from the influence of the Humber River. The contribution of the Humber River to pollution had been well documented in the Toronto Area Watershed Management Strategy Study (TAWMS) conducted by the Ministry of the Environment (1983). Accordingly the decision was made to sample this area less intensively (2 times weekly) during the summer period until some physical improvements had been carried out. Included in these improvements were the construction of an earthen wall to divert the flow of the Humber river outside the concrete breakwall which encloses the western beaches. It was hoped that this measure would lessen the bacterial loading in this area. The wall was completed by July 1, 1984 and indeed by August 1, 1984 a gradual improvement was noted.

In the Eastern beaches combined sewer outfalls were considered to be the major factor and accordingly a more intensive sampling programme (7 times per week) was undertaken. In this way rainfall/runoff events and their effects on beach water quality could be carefully monitored.

Throughout the beach system sampling methodology was standardized with the sampler wading into the water to chest height depth using accurate landmarking to ensure consistent station location. Parameters were changed to include fecal coliform, Escherichia coli and Pseudomonas aeruginosa enumerated by the "membrane filter" test.

Although this year's data have not yet been analysed intensively raw results would tend to suggest that a system of regular beach closings for an as yet undetermined period is indicated. It is hoped that a reasonably accurate predictive model can be developed to aid in this process. The Department of Public Health will be issuing a full report on the 1984 seasonal work in November 1984.

Note: All sampling results used in determination of beach closings were computed in 10 term log means.

4. POLICIES AND STRATEGIES TO DEAL WITH WATER QUALITY ISSUES

4.1 Chemical pollutants

4.1.1 Niagara River

The problems associated with the chemical contamination of the Niagara River and surrounding areas are particularly intractable because the river is an international border between the U.S. and Canada. Unfortunately the state of the Niagara River and therefore Lake Ontario is less important to the Americans because relatively few U.S. communities of any size draw their drinking water from the lake. In contrast, nearly 4 million Canadians, or approximately one-sixth of the total population of Canada, are supplied with drinking water from Lake Ontario. In addition, many heavy industries are located on the U.S. side of the Niagara Rivers, whereas the Canadian side is relatively unindustrialized. For these two reasons the Canadian government should urgently lobby the U.S. federal government and the N.Y. State government to remediate the Niagara River ecosystem as completely as possible. We cannot expect the situation to improve without such lobbying.

There are three specific policies which, if adopted would ameliorate the situation. Firstly, instead of attempting to isolate leaking hazardous waste disposal sites from the environment, it would be preferable to remove the wastes by excavation and dispose of them using modern disposal technologies (such as high temperature incineration). This option, although more expensive in the short term, would be cheaper in the long term, because of the costs of the necessary perpetual care of *in situ* managed wastes. Secondly, the process by which discharge permits are issued should be reviewed by the N.Y. DEC along the lines suggested in section 2.1.1. This would regulate discharges more effectively. If low maximum concentations were set, and the system was strictly enforced, it is likely that contamination of the Niagara River would decrease. Thirdly, because many

industrial wastes are discharged to the river indirectly via municipal wastewater treatment systems, the contaminant levels in these sytems should be as low as possible. This could be done by implementing strict pre-treatment standards for industries which discharge into municipal systems and by ensuring that they are as efficient as possible at removing trace levels of contaminants. All three of these policies should be strenuously advocated to the N.Y. DEC by the Canadian government.

In order to ensure that Canadian lobbying is as effective as possible I would suggest that the following points be considered. Firstly, the IJC should be encouraged to adopt the positions outlined above as policy, so that this binational organization can also lobby for them. Secondly, it would be adviseable for all of the positions mentioned above to be already implemented in Canada. Unless this is the case Canada could be accused of being in a situation of 'Do as I say, but not as I do'. Therefore, it would be appropriate for the provinces to set limits for point sources discharges of chemicals with the purpose of ensuring that they are effective in reducing waste loadings to local ecosystems. It would also be appropriate for the status of Canadian sewage systems to be reviewed for;

a) the need for pre-treatment standards

b) their effectiveness at removing trace levels of contaminants.

Obviously, projects such as these will require substantial provincial cooperation and probably the assistance of many municipalities. But it should be recognized that unless we have environmental pollution controls that are at least as effective as those in the U.S. in general, and New York State in particular, we cannot hope to lobby effectively for any additional improvements in the Niagara River.

4.1.2 Atmospheric deposition

As mentioned in section 2.1.2 above, atmospheric depositon has only recently beeen recongized as being a significant source of contaminants to the Great Lakes ecosystem. In my opinion, this international issue would be best addressed by the IJC. Therefore, I would suggest that the Canadian government should request the IJC to investigate the sources, magnitude, types, and effects of atmospheric deposition.

Following such a research project, atmospheric deposition should be minimized by requiring known sources of discharges to limit their releases by employing the 'best available technology'. As discussed above, in order to effectively lobby this position with the U.S., equivalent Canadian requirements must be already in

place. Another alternative would be to establish an IJC agreement, similar to, or incorporated into, the Great Lakes Water Quality Agreement, which would limit sources of atmospheric deposition in both countries.

4.1.3 Sewage

It is generally recognized that both the chemical and the bacteriological quality of sewage effluents are an important determinant of water quality in Toronto's nearshore zone. This has been discussed in sections 2.1.3 and 2.6 above. It is therefore hardly surprising that efforts are being made to improve the sewage system in Toronto.

The largest program being undertaken is to separate storm sewers from combined sewers. This has the effect of reducing the proportion of storm sewage in the combined sewers, which in turn results in a smaller proportion of sanitary sewage being discharged untreated when the combined sewers overflow during heavy or prolonged rainfall. Another result is that a smaller proportion of storm water receives treatment before being discharged to the lake. Unfortunately, storm water is contaminated both bacterially and chemically and there are also illegal connections between sanitary sewers and storm sewers. Although I support the sewer separation program, because it minimises the amount of untreated sanitary sewage entering the lake ecosystem, I am also concerned about the quality of untreated storm water being discharged into the lake. Sewer separation is not a panacea, and I would encourage the Canadian government to further research the possibilities for storm water treatment. These include retention or settling tanks and disinfection of storm water effluents, although the latter will obviously not ameleriorate the effluent's chemical quality.

Other programs include engineering solutions which divert or transport sewage further offshore. Firstly, in the summer of 1984 a diversion for the Humber River, which is badly contaminated with sewage, was constructed to divert the flow further offshore. Secondly, Toronto's main treatment plant outfall pipe is currently being redesigned. This will probably include lengthening the pipe and increasing the flow rate, and could also include relocating the pipe. In my opinion, these programs are interim solutions only because although structural diversions are effective for controlling the bacterial contamination of our beaches (bacteria cannot reproduce in cold, deep lake water), they are not effective in controlling chemical contamination. More emphasis should be given to permanent solutions which would improve the bacterial and chemical quality of effluents.

There are several strategies and policies which could contribute to an improvement in effluent quality. These include the establishment of more rigid pre-treatment standards for discharges into the system, and thorough enforcement of these standards. This could be implemented by strengthening municipal sewage by-laws.

Another strategy could involve upgrading existing treatment facilities to use 'advanced wastewater technologies'. These include carbon bed filtration. Although it is still a relatively undeveloped technology, I would encourage research in this area.

A third strategy could be to further encourage waste recycling and safer disposal of unrecyclable hazardous wastes. Both industries and residents are responsible for the presence of hazardous wastes in sewage, and could be encouraged through education programs and financial incentives to recycle where possible, and dispose of other hazardous wastes in an environmentally sound way. For example, municipalities should be encouraged to initiate hazardous waste pick-up services for wastes such as products used for home renovations and unwanted pesticides. These have already proved successful in the few areas of Ontario where they have been introduced on a trial basis.

4.1.4 In place pollutants

The problem of in-place pollutants was outlined in section 2.1.4 above. It is difficult to envisage a common strategy or policy for management of this type of degraded ecosystem because local conditions are so variable. In my opinion, therefore, the management of in-place pollutants should be considered on a case-by-case basis. Such considerations should focus on the least disruptive method for remediating the ecosystem in both the long and short term. In some cases it may be more appropriate to remove contaminated sediments by dredging, and in others, particularly in depositional areas, may be more appropriate to allow cleaner sediments to overlay the contaminated ones. Therefore, decisions should be made on an individual basis.

4.2 Biological monitoring

The occurrence of fish cancers, as described in section 2.2 above, could be interpreted as an 'early warning system' for the occurrence of human health effects. This is one example of 'biological monitoring', in which non-human biota (either whole organisms or parts thereof) are used to predict possible contamination of ecosystems and/or potential human health effects.

This approach can assess the hazards associated with exposure to one, or a mixture of chemicals. It is usually much more rapid

than chemically analyzing samples, because living systems respond quickly to alterations in their environments. It cannot, however, identify specific chemicals, only their effects.

One example of a biological monitoring system is the use of an algal species to predict metal contamination (18). This experimental system is being studied by researchers at the Canadian Centre for Inland Waters, where radioactive carbon dioxide uptake is being used as a measure of algal metabolism. This system has considerable potential and is an excellent example of biological monitoring.

I would encourage the Canadian government to continue and even increase the funding given to such research projects. As more biological monitoring systems are developed, it should be possible to incorporate biological based standards into water quality and other environmental legislation. Such standards could embody the protection of the public's health more appropriately than the present standard setting process, which is based on the effects of individual chemicals as judged in a laboratory environment.

4.3 Alternative water filtration and disinfection systems

In recent years alternative water filtration and disinfection systems have been extensively studied in the U.S. There is no simple alternative to conventional sand filtration, but activated carbon adsorption is often cited as an improvement on existing systems.

Carbon and other adsorbents have been used in water treatment since ancient times. Today in Canada and the United States, activated carbon is used in a few drinking water treatment facilities for taste and odour control. In European water treatment, activated carbon is used at approximately 100 plants, primarily for removal of organics from water supplies, and in some instances for control of chemical spills. Additionally, numerous pilot plant studies are underway in the United States to determine the suitability of activated carbon for treating particular water supplies.

Many factors influence the adsorbability of a substance by activated carbon. In general, organic compounds are adsorbable while inorganic compounds are relatively inadsorbable. There is evidence, however, that certain trace metals (chromium, mercury) can be adsorbed by activated carbon (20). The less soluble a compound, the more adsorbable it usually is. As a rule, large compounds are less soluble. Thus, increasing size results in increasing adsorption. This may explain why trihalomethanes are not adsorbed well by activated carbon, while large natural organic compounds are adsorbed relatively well.

In European water treatment systems granular activated carbon (GAC) is used typically to reduce organic content of water prior to disinfection. This practice reduces disinfection demand and reduces formation of chlorinated organics when chlorine is used as a disinfectant.

Often in European water treatment, GAC is used in combination with ozone for pre-treatment. Studies show that pre-treatment with ozone encourages microbial growth on activated carbon (21). Such biologically activated carbon (BAC) has a much longer life than ordinary GAC, often remaining active for several years (16). Enhanced removal of organics by activated carbon following ozonation has been reported for several full scale treatment systems in Europe. Unfortunately, microbial growth on GAC beds is common and extensive growth can result in organisms sloughing off into treated water. Concerns have been raised about pathogenic microorganisms finding their way into finished water via this route. Studies have been done of bacterial quality of GAC-treated water. To date, the most common bacterial strain found in GAC beds and effluents is Pseudomonas, an "opportunistic" pathogen which was found in many but not all of the effluents tested in 13 studies reported in the U.S. study Drinking Water and Health (16). Fecal indicators have not been found in GAC treatment effluents, nor have Salmonella, Shigella, Vibrio or Yersinia.

Alternative disinfectants currently being studied in the U.S. and Europe include ozone, chlorine dioxide and chloramines (which are used as the residual disinfectant in Toronto's distribution system).

Ozone

Ozone gas is a powerful oxidizing agent used as a disinfectant in drinking water treatment because of its excellent bactericidal and viricidal abilities. Ozonation is used widely as a water treatment process in Europe, where it was introduced early in the century. Although Quebec has 20 facilities, its use in North America water treatment is relatively rare.

Ozone may be used at different points in the water treatment process and for a variety of reasons. In European water treatment facilities uses of ozone include: iron and manganese removal, oxidation of organics, taste and odour control, destruction of coliform bacteria and viruses, and flocculation. Thus, ozone may be used early in a water treatment system for iron and manganese removal or flocculation; at an intermediate stage, following filtration, for oxidation of organics and preparation of biologically activated carbon columns; and near the end of the process for inactivation of viruses and bacteria. Because ozone

does not provide residual disinfection it is rarely used as the terminal disinfection step in drinking water treatment.

In terms of its biocidal efficiency, ozone outranks all other oxidizing disinfectants including chlorine. Ozone inactivates microorgansims, such as E. coli and enteroviruses. In fact, ozone has been judged to be two to three orders of magnitude more efficient as a disinfectant than free residual chlorine (22).

Like chlorine, ozone reacts with organic matter in water but relatively little is known about its reaction products. There is speculation that potentially hazardous peroxides and epoxides could be formed by ozonation, but this hypothesis has not been verified.

There have also been several studies on the mutogenic potential of ozonated water. One study showed that ozonation reduced the mutogenic activity from that in raw water, while chlorination increased it (23). Other studies have been inconclusive. To the present time, there have been no studies reported of human health effects of consuming ozonated water, although such research is underway in the Netherlands. It is clear that additional research is needed to identify specific mutagens associated with ozone treatment and to determine why ozone seems to reduce mutagenesis under some conditions and not others.

Chlorine dioxide

Chlorine dioxide is a chemical oxidant used widely for bleaching textiles and wood pulp. In North America, chlorine dioxide was first used in large-scale water treatment in 1944 at Niagara Falls, New York, as a control for phenolic tastes and odours. Today chlorine dioxide is used in approximately 85 water treatment plants in the United States for the purpose of removing iron, manganese, taste, odour and colour. In Europe nearly 500 plants use chlorine dioxide for primary and residual disinfection. Chlorine dioxide was used in Toronto for taste and odour control until 1968, when it was discontinued due to lack of effectiveness in controlling phenolic tastes.

In both pre-treatment and intermediate stages of water purification, chlorine dioxide may be employed to destroy bacteria and viruses. It is a rapidly acting, effective disinfectant which inactivates coliform bacteria, common enteroviruses and pathogenic amoebae.

Recent review of research on health effects of chlorine dioxide indicate that chlorite interferes with the oxygen carrying capacity of red blood cells by forming methemoglobin in several animal species and humans (the principal reaction product of

chlorine dioxide). Additionally, chlorite damages red blood cell membranes, depletes levels of glutathione and increases concentrations of hydrogen peroxide. These changes result in hemolytic anemia. Other toxicological research on chlorine dioxide and its by-products has shown that these substances interfere with DNA synthesis in intestines, liver and testes of rats at doses of 10 mg/L daily for three months. In addition, there is evidence that chlorine dioxide forms mutagenic compounds in water, but not as a result of chlorination of organic materials.

Epidemiological research on health effects of chlorine dioxide has been done with both adults and infants. A study of healthy adults exposed to chlorine dioxide disinfected drinking water found no significant evidence of hematologic effects over a three-month exposure period (24). A study of mortality and morbidity of newborns found greater incidences of premature births and greater weight loss after birth than normal.

In summary, chlorine dioxide and its reaction product, chlorite, are demonstrated blood oxidizing agents which may have adverse health consequences, particularly for infants and certain susceptible groups of adults. For this reason, use of chlorine dioxide in water-treatment was banned recently in Denmark. From a public health viewpoint, these findings are compelling enough that I would recommend that chlorine dioxide not be considered as an alternative to chlorine for disinfection of Toronto's water supply.

Chloramine

When ammonia is added to treated water it combines with free chlorine and the resulting product is known as combinec chlorine or inorganic chloramine. Chloramine is a more stable residual disinfectant than chlorine, lasting longer in the distribution system. Additionally, it reduces tastes and odours associated with chlorophenolic compounds.

The health effects of chloramines have been studied very little. Like chlorine dioxide and its reaction products, chloramines oxidize red blood cells in humans. Chloramine is also mutagenic and the U.S. National Cancer Institute is currently conducting bioassays to assess its carcinogenic potential.

As concern mounts regarding chemical contamination of drinking water and failure of conventional treatment systems to eliminate chemicals, pressure to consider activated carbon has increased. The U.S. EPA has been conducting pilot studies in several

locations for more than a decade, and recently it was announced that full-scale plants will be built in Cincinnati and New Orleans.

In relative terms, Canada lags far behind in efforts to establish the effectiveness of GAC and other alternatives to conventional treatment. Although, it is obviously unnecessary for us to repeat research already in progressin the U.S., it would be desirable for Canada to develop expertise in this area. Specifically, a federal research program should be initiated to assess the effectiveness of these alternative systems on Canadian water supplies, which are in many cases differences in quality from U.S. water supplies. The first pilot plant study of GAC in Canada is about to be undertaken by the Ontario Ministry of the Environment (MOE), which recently announced its intention to conduct such a study in the Niagara region. The aim of the MOE's study is to re-examine current treatment processes with regard to chemical removal by optimizing conventional treatment and combining it with GAC. There are unfortunately no plans to study alternative disinfectants such as ozone or chlorine dioxide. Despite this drawback, the study is amuch needed first step in reviewing Canadian water treatment practices in light of water quality data.

I hope that this study will be fully exploited by the MOE. For example, it would be more useful to have data about effects of alternative disinfectants (i.e., ozone, chlorine dioxide) than simply to have additional information on chlorine, the treatment effects of which are well known. In light of a growing trend towards combined GAC-ozone systems, the MOE might consider capitalizing on the opportunity to study this treatment combination. In addition, as this study is designed to be a test of how conventional treatment processes perform when they are optimized, the most rigorous testing conditions should be used. In other words, tests should be conducted under worst case conditions.

4.4 Improving drinking water legislation

There are several ways in which existing legislation could be revised. Firstly, it would be possible to incorporate drinking water regulations into the Ontario Water Resources Act. This would have the advantage of not requiring any additional legislation. Secondly, a provincial or federal Safe Drinking Water Act could be introduced. In April 1982, such an act was introduced into the Ontario Legislature as a private member's bill, and Health and Welfare Canada is currently discussing the feasibility of a federal Act. Setting mandatory standards is complex, and there is a danger that such standards will be the lowest common denominator. Enforceable standards will have to be

technically feasible, and funds should be made available for upgrading non-compliant facilities.

One of the pre-requisites for the development of mandatory standards would be a national survey of Canadian drinking water. Unfortunately, there has never been a comprehensive national survey of organic and inorganic chemicals in Canadian drinking water, although several selective surveys have been undertaken. Therefore little is known about the chemical status of our drinking water. Such a survey would be required for the development of mandatory standards, and I would encourage the federal government to undertake a national survey as soon as possible.

Another way to improve existing drinking water legislation would be to strengthen the role of public participation in the standard setting process.

This could be done as follows. Firstly, the appropriate government agency would publish a notice announcing its intention to establish policy on a given subject. This could include environmental standards. Secondly, any interested parties, such as representatives from industry, unions, community groups and public interest groups would be allowed to submit written briefs or make oral presentations at public hearings held to consider the subject in question. The government agency concerned would then renew the contributions, together with their own research, and publish its decision, together with a complete rationale.

In summary, I tend to support the establishment of mandatory drinking water standards, providing the necessary preparative work is successfully completed.

4.5 Studies on the effects of chemical exposure

Section 2.5 above outlined some of the problems associated with assessing the health effects of exposure to chemicals. This problem is not easily solved and points out the inadequacies of the scientific method itself. In the classical approach to hazard assessment the effects of one chemical are considered in isolation, but in the real world this situation rarely occurs because we are all exposed to a multitude of chemicals from various sources every day. It is doubtful that this traditional approach will ever be able to assess even a proportion of the health effects associated with the interactions and combinations of chemicals. Given this situation, we must look for new ways to improve the assessment of risks associated with chemicals in drinking water. One possibility is the development of biological monitoring techniques, as discussed in section 4.2 above.

Most of the scientific evidence which is used for determining whether a water contaminant is hazardous to humans is based on animal experimentation. Although the correspondence between animals and humans is often good, it can seldom, if ever, be completely accurate. Therefore, there is a need for epidemiological studies. Unfortunately, there has been very little epidemiological investigation of the impact of water contaminants on human health. There are two main reasons for this:

a) it is extremely difficult to quantify exposure levels, and dose levels, of humans to particular contaminants,

b) it is extremely difficult to separate the multiple sources of exposure to contaminants and to isolate specific factors in these exposures and/or to identify characteristics of people (either behavioural or genetic) which may contribute to disease.

Such methodological problems are inherent in all types of epidemiology, but are more acute in the epidemiology of environmental contaminants. These problems have seriously impeded the development of such studies, but in my opinion, it would be highly desirable for them to receive a higher priority on the national research agenda.

4.6 Improving the bacteriological quality of Toronto's beaches

There is no single strategy or policy that would completely remediate the bacteriological contamination of Toronto's beaches. Improvements in the sewage system have already been discussed in section 4.1.3 above. Many of these improvements would also improve the bacteriological quality of Toronto's beaches. It is also evident that such improvements would also benefit the bacteriological quality of the local rivers and streams, and hence further ameliorate the beaches ecosystem. Thus, improving the sewage system would reduce both chemical and bacteriological contamination not only in rivers and streams in the Toronto watershed, but also in the beaches themselves. It is therefore logical to emphasise this policy option, and indeed this approach has already been implemented by the Ontario Ministry of the Environment to some extent.

Spraying gulls' eggs with kerosene is a less permanent solution that may reduce the amounts of gull excrement in the short-term, and hence reduce the bacteriological contamination of the beaches. Spraying must be done in the nesting season (spring) and would be required wherever the size of the population warranted it. Another solution which would control the gull population include

removing the eggs from the nests. Alternatively, a more permanent solution, such as habitat modification, may be desirable..

Other suggested policy options for improving the bacteriological quality of the beaches have included chlorination of the entire nearshore zone. Although this approach would probably achieve the desired result, it is only a short-term solution and would further disturb the already damaged nearshore ecosystem. Not only would bacteria be destroyed, but also many benthic organisms and much plant life. Indeed, prolonged exposure to chlorine and its related compounds could result in the development of virtually sterile areas adjacent to the beaches and shoreline. I therefore cannot endorse this policy option at the present time.

5. CONCLUSIONS

This brief has outlined some of the problems associated with the environmental and public health aspects of a federal water policy. Although I have emphasised Toronto's problems, many of these have national, and even international dimensions.

In my opinion, we must accept that an important strategy to protect the public's health is the protection and restoration of the environment. As human beings, we are an integral part of the environments we live in, and we cannot be separate from them. Everything that degrades the quality of those environments, either locally or globally, will eventually degrade the quality of human life to some extent. This has been called the 'ecosystem approach' and it is now well-established in the management of the Great Lakes basin. It is also the only realistic long-term approach for a federal water policy.

An ecosystem approach can best be implemented at the federal level, but it will be necessary to transcend the regionalism caused in part by Canada's size and to develop a strong federal leadership role in these matters. These will facilitate the development of a comprehensive national water management policy which can take account of all the relevant ecosystem interactions.

Another major barrier to the development of an ecosystem approach for water management is the myth of superabundance. Canada is still perceived as a land of virtually limitless water supplies, which can be used to dilute the waste products of our society. This has been discussed briefly in my brief but deserves further attention. Our water supplies, even in Canada, are limited and we cannot continue to contaminate them. This is partly because of adverse effects on the natural environments, and partly because many of these same supplies are also used as sources of drinking water. The Great Lakes basin is an excellent example of this. It is used as a receptacle for industrial and municipal wastes, yet

it is also a source of drinking water for a substantial proportion of the Canadian population. In my opinion, the clean-up of this ecosystem, although in progress, has been slow and should be expedited.

In conclusion, I would encourage the federal government to develop a strong, comprehensive, national water policy which will protect and enhance the quality of Canadian water supplies so that they can be used safely not only by human beings, but by all the plant and animal species that we share them with.

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